Grid Limitations

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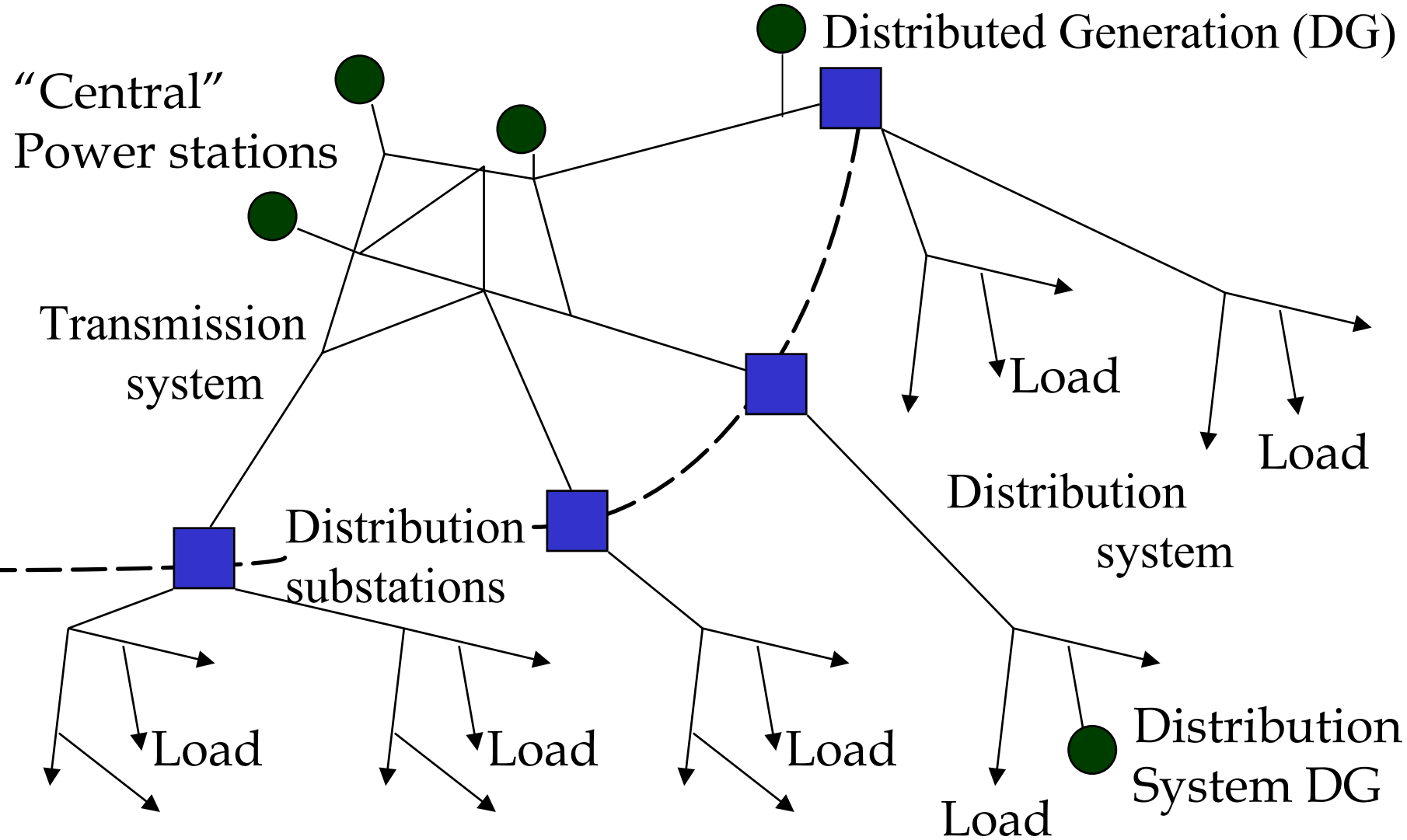
Ross Baldick
Department of Electrical and
Computer Engineering
The University of Texas at Austin

Outline

- Overview of the generation, transmission, and distribution system,
- Evolving roles of electric transmission,
- Planning of the electricity system,
- Merchant generation,
- Grid limitations,
- Increasing capacity of transmission,
- Implications for distributed generation:
  - Concentrate on “on-grid” applications,
- National energy policy.

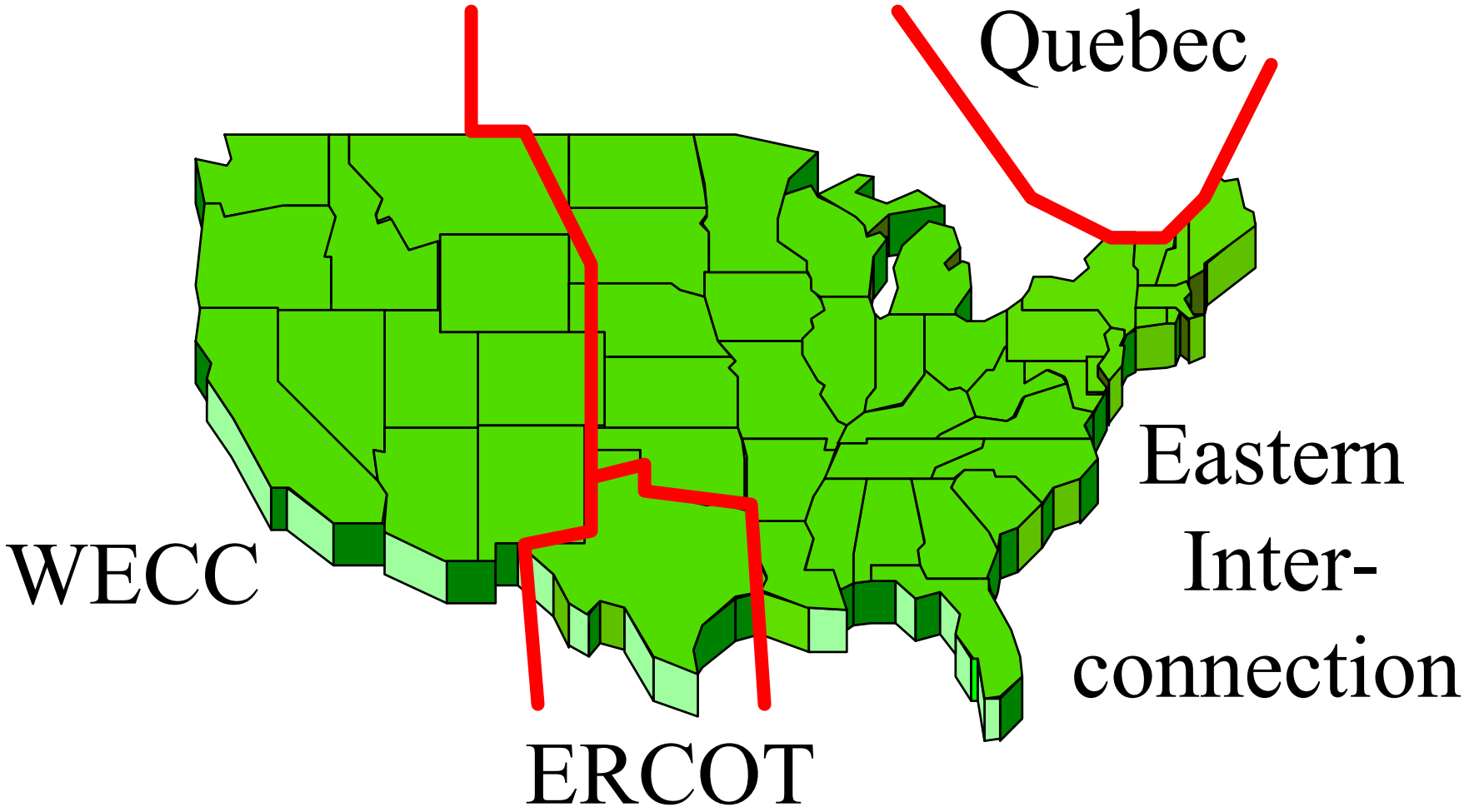
Overview of Generation, Transmission, and Distribution.



Transmission.

- Provides for “long-distance,” “bulk” transport of energy,
- Accounts for about 10% to 20% of total cost of electric power system,
- Inter-connects almost all electric generation and demand in North American into four huge systems:
  - potential for trade over large geographical area.

Inter-connections in North America



Evolving roles of transmission.

- Bringing power from remote generators:
  - Historical trend to ever larger generators,
- Inter-connecting utilities to allow sharing of generation “reserves:”
  - Provide reliability more cheaply,
- Enabling trade:
  - Opportunities to buy and sell,
- Mitigating market power:
  - In restructured electricity markets.

Planning of the electricity system.

- Historically, utilities planned generation and transmission jointly to meet growing demand:
  - large central generation projects had long lead times allowing for transmission to be built,
- Restructured electricity markets leave generation planning (mostly) to the market:
  - “merchant generation” building smaller generation projects with shorter lead times.

Merchant generation.

- Largely unregulated (economically) owners of generation capacity:
  - still face environmental regulations,
- Sell energy at market rates,
- Assume (most) risk of business decisions,
- Harness competition to drive costs down and develop technology,
- Considerable merchant development in Texas,
- Can be central or distributed generation or even "dispersed" resources such as wind power.

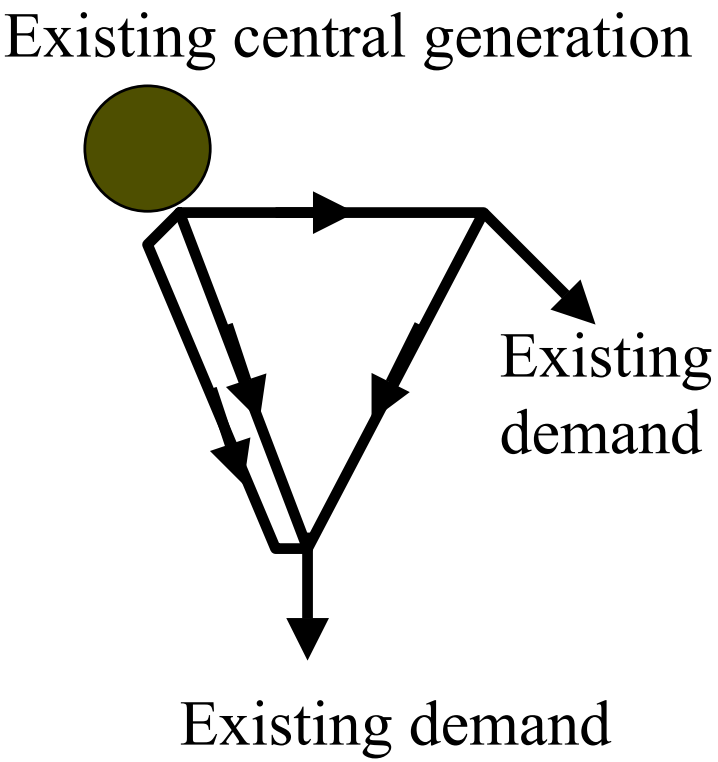
Transmission.

- Transmission mostly remains regulated:
  - "rate of return" paid on investments,
  - incentives for developing technology and upgrading capacity tend to be weak,
- Difficult to plan and build new transmission,
- Limitations on moving electric power are prevalent in North America, particularly into urban areas.

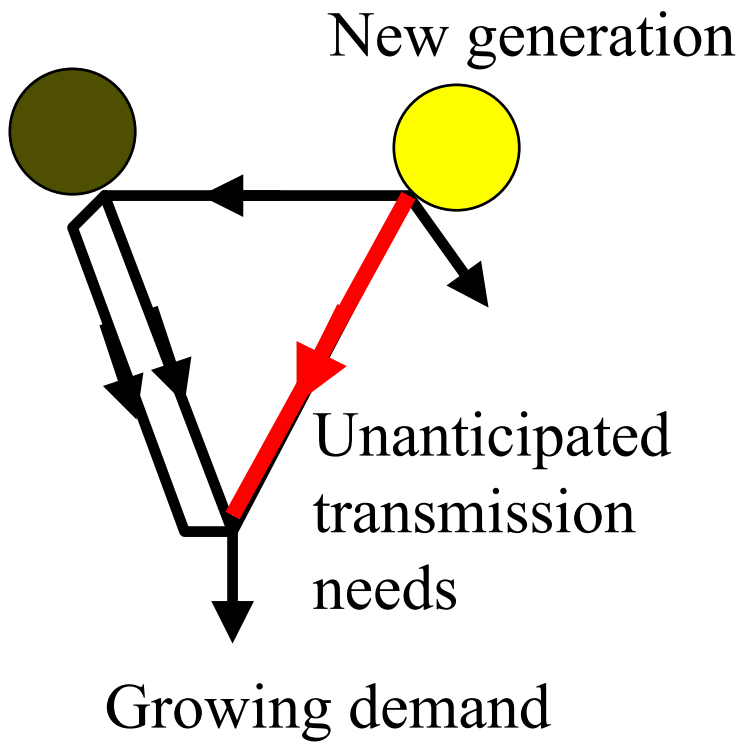
Grid limitations.

- Limit trade opportunities,
- Limit opportunities for development of merchant generation,
- Create local market power:
  - particularly in “import limited” areas,
- Cost of grid limitations on trade and market power may be large compared to the construction cost of transmission.

Grid limitations and new merchant generation.



- Existing system.



- New generation planned by merchant.

Technology to increase capacity of existing transmission system.

- Existing technologies with potential for further development and deployment:
  - "Reactive compensation," "phase angle regulators," "Flexible AC transmission," (FACTS), "high-voltage DC light" (HVDC light),
  - Range of costs and characteristics,
  - Several of these are already heavily deployed.
- Rebuilding lines to increase capacity:
  - "Re-conductor" lines,
  - Continuing improvements in metallurgy are providing better conductors.

Technology to increase capacity of existing transmission system.

- Development of technology to allow temporary upgrades and re-locatable equipment:
  - Fast response to announced need,
  - Re-locatable resources reduce risks of "build it but they do not come,"
  - Used extensively in United Kingdom, similar proposals by affiliated company in United States,
- New technologies:
  - Super-conducting cables,
  - Super-conducting magnetic energy storage (SMES), a distributed energy resource,
  - Test applications, potential for large improvements.

Alternatives to increasing transmission capacity.

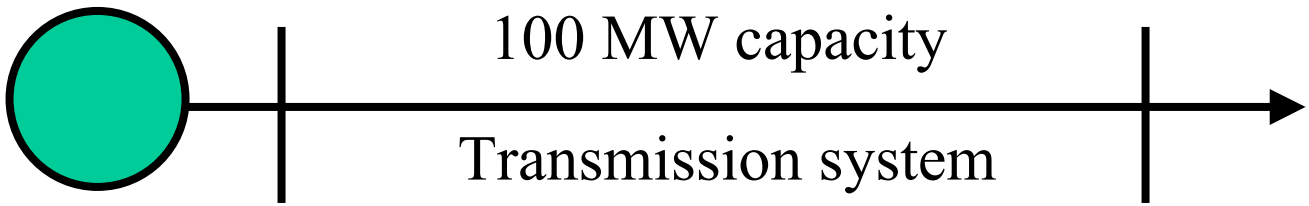
- Given a growing demand:
  - build new transmission (or increase capacity of existing transmission) and build new (or access existing) central generation, or
  - build new distributed generation near demand center (and avoid need for transmission).

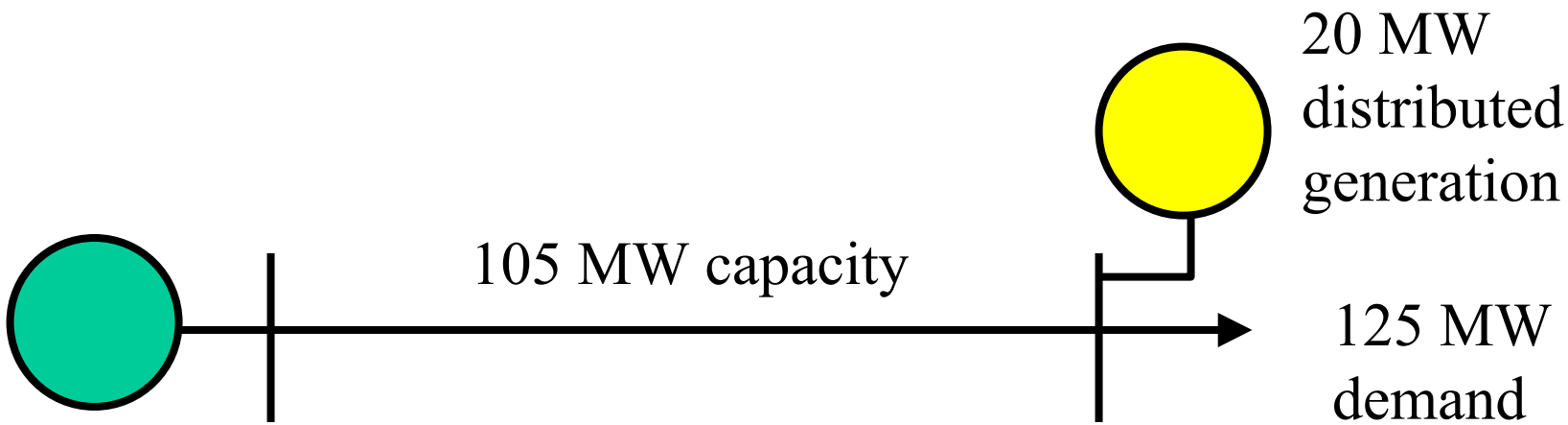
Distributed generation resources.

- Distributed generation reduces needs for imports and reduces "transmission losses,"
- Helps to mitigate market power in import limited areas,
- Geographically well-positioned generation can provide "voltage support" that enhances the capability of the transmission system:
  - conversely, "dispersed" DG such as wind power typically requires additional transmission.

Distributed generation resources.

Central power station





Distributed generation resources, continued.

- May not be economically viable on basis of selling "base-load" energy alone:
  - Energy conversion efficiency may not be as high as that of a large, central power station,
  - "Peaking" opportunities viable if there is an energy market that differentiates prices over time:
    - "Time of use" meters to reflect variation in prices,
  - How to set up transmission prices that "credit" these resources for the enhancement to transmission that they provide?

Distributed generation resources, continued.

- Transmission expansion, pricing, and interconnection policy have significant effects on distributed energy,
- Generation and transmission are partial substitutes for supplying electricity:
  - difficult to have effective competition in one sector while the other is regulated.

Demand center versus Distribution system DG.

- Locating close to demand center potentially avoids need for new transmission and can even enhance transmission capability and reliability,
- However, distribution system DG may not provide these benefits without additional distribution system infrastructure:
  - Integration of distribution system DG requires new or modified distribution system infrastructure in addition to time-of-use meters,
  - Increasing the reliability of end-use customers typically also requires “ride-through” capability using uninterruptible power supply with energy storage.

National energy policy considerations.

- Difficult to appropriately regulate transmission because of its partial substitutability with generation:
  - competition (merchant generation) versus
  - regulation of transmission,
- How to price scarce transmission capability and "credit" distributed resources?
  - much of United States still uses property rights for transmission that explicitly violate physics,
  - recent FERC decision will change this.

National energy policy considerations, continued.

- How to plan expansion of the transmission system?
  - want incentives that encourage development of the "right" portfolio of new generation resources,
  - encourage entrepreneurial activity and technological development in generation and transmission,
  - accommodate growing demand.

National energy policy considerations, continued.

- Should "merchant transmission" be encouraged, or the regulated status quo maintained, or alternative regulatory approaches taken?
  - Who will be motivated to invest in technologies such as re-locatable equipment and motivated to develop new technology,
- Should distribution system infrastructure be upgraded to accommodate distribution system DG?
  - Including integration of information technology into distribution system to enable control and monitoring.

Conclusion.

- Transmission expansion is limited in most urban areas in the US,
- Demand center located generation offers (competing) alternative for meeting demand,
- Policy considerations on regulation of transmission, pricing of transmission capacity, planning and construction of new transmission capacity, implications for distributed generation.